DigiPrime

Digital platform for circular economy in cross-sectorial sustainable value networks

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Open call type "B": Pilots in new sectors using the DigiPrime digital platform, services, and basic data transfer functionalities

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Annex 9: Technical Annex

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9.1 Introduction

9.1.1 Digiprime architecture

The overall architecture level of the DigiPrime platform includes:

- A Multi-node federation structure, replicable on different existing and additional sectorial platform instances and with easy access for users, which will support the future systematic creation of cross-sectorial circular value-chains.
- A Semantic data infrastructure based on ontological repositories and semantic search, able to manage and standardize the Babel of information coming from heterogeneous nodes.
- A Data Policy Framework to ensure privacy, security, authentication and authorization policies to any information shared among registered users.

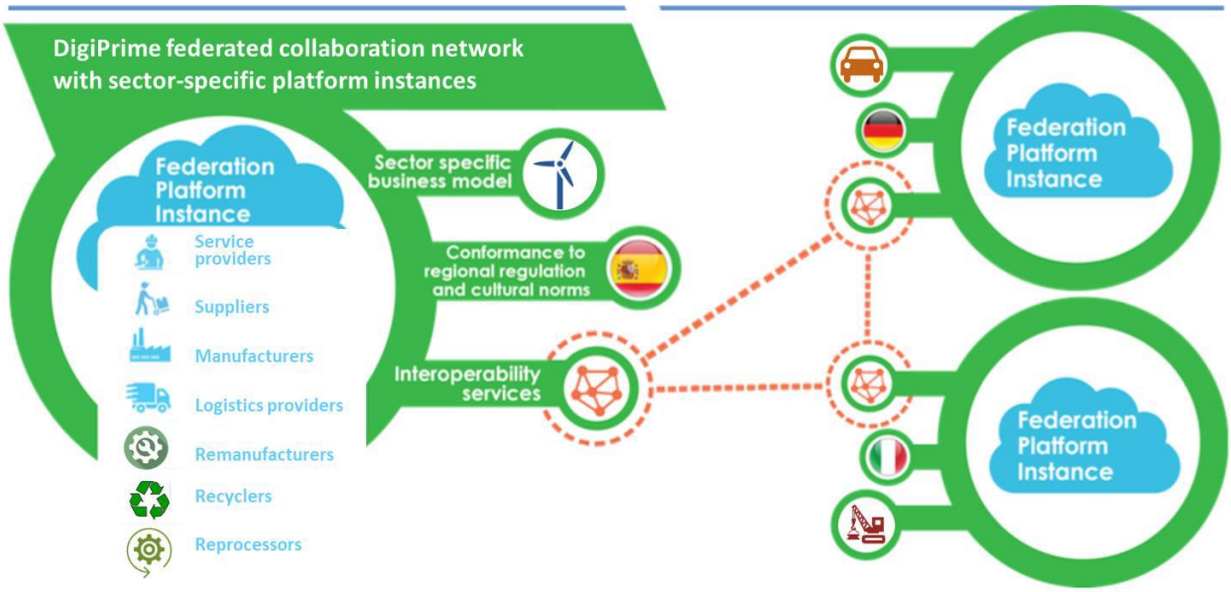

Figure 1: DigiPrime Federation-based architecture

The DigiPrime architecture distinguishes among:

Value-chain Oriented Services (VOS): horizontal services that can be made accessible to other nodes of the federation, to offer access to information of interest across sectors, and

Operational Services (OS): vertical services within a node, used by companies internally, mainly to support decision making aiming at improving the effectiveness and profitability of the circular business processes.

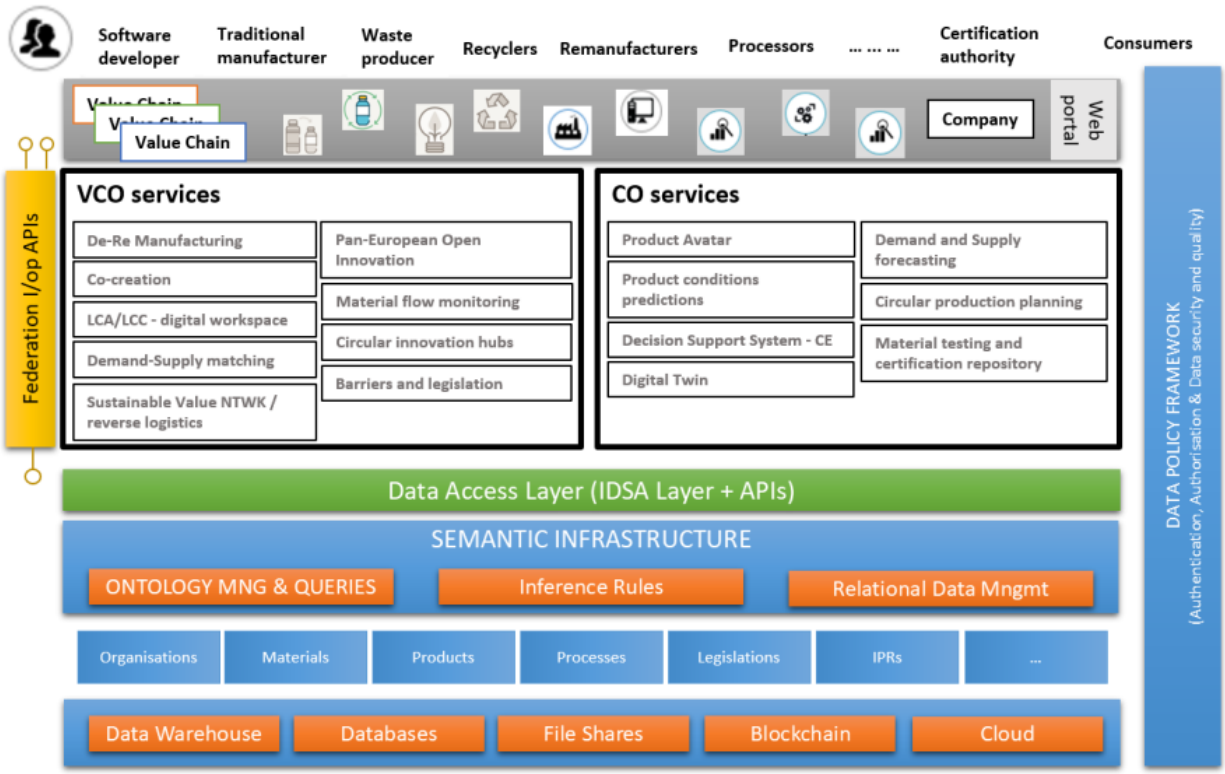

Figure 2: DigiPrime Platform node architecture

A specific description of each single service is reported in the following section

9.2 Description of the existing DigiPrime services

DigiPrime existing services	
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3.2 Product Co-Creation	4.3. De and remanufacturing Decision Support System *4.3.1 – Decision Support System for Circular Economy (DSS-CE)* *4.3.2 Decision Support System for Composite Recycling (DSS4CR*)
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4.1 Product in-use data acquisition and monitoring	

In the following pages there is a description of each single service

3.1 - De- and remanufacturing oriented product information management

Objective

Service targeted to Circular Economy value chain stakeholders. In this service, datasets collecting information and technical files about commercial products are organized and made available for the users. The user can set its preferences according to the type of information and product families of interest and receive customized notifications. The user can also upload information and files not yet available.

Methodhology

Datasets collecting product information and technical files are organized highlighting the reference product, the product family and which type of stakeholder (e.g. recycler, remanufacturer, etc.) would be interested in having access to it. Combining the dataset structure and the preferences set by the user, the service provides customized notifications about new information available on products of interest and a dedicated search engine.

Outputs

- *At the first login, the user is notified about all the information and files available on the product families of interest.*
- *More detailed querying can be made exploiting the dedicated search engine.*
- *If a new information about a product of interest is made available, the user is notified.*
- *If a new product which belongs to a product family of interest is added, the user is notified.*
- *If another user search for an information which might be available, the user is notified.*

3.2 – Product Co-Creation

Objective

The Co-Creation service is a tool thought to help all companies solving challenges or proposing solutions, through a process of collaboration in an open innovation approach. It's directed at all the stakeholders that want to interact giving and receiving feedbacks, ideas, or suggestions on specific topics and challenges.

The tool gives all users that have ideas and creativity, the possibility to insert their ideas to solve the challenges, to answer surveys or identify companies' problems which needs to be solved.

Methodology

The tool aims at creating a table where the collaboration among different actors is encouraged through a social media approach.

The users can create challenges describing their needs, or ideas, to propose innovations and solutions. They can interact among each other by proposing ideas to challenges, adding tags to mark the contents, giving feedbacks through surveys, comments, like and dislikes.

Outputs

Definition of new and innovative products and processes which can be virtually validated by the community of stakeholders.

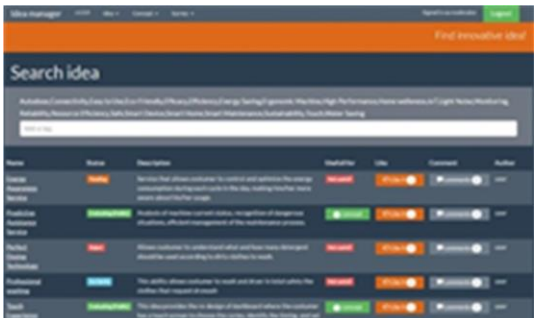
Engagement of the community of stakeholders.

Identification of many potential solutions to challenge proposers issues.

Identification of potential usages of an idea proposer solution.

Possibility to interact with other stakeholder which can also be from outside the company.

Possibility to receive feedbacks with different level of detail.



3.3 - LCA-LCC for eco-design

Objective

*The eco-design needs to take into consideration the full life-cycle of the product with special focus on dismantling and second life of the components. Eco-design of products bases on the interaction of value chain stakeholders and is part of the LCPA (Life Cycle Performance Assessment). Different **product** and **process concepts** are compared and assessed to find the optimal ecological (LCA) and economical (LCC) solution.*

Methodhology

*For **LCC** (Life Cycle Cost calculation) the NPV (Net Present Value) is the key part. All other considerations are built around. The Screening **LCA** (Life Cycle Assessment) is the implemented assessment method for the ecological assessment. Both methods are part of the BAL.LCPA software. BAL.LCPA is an commercial tool which will be connected to the DigiPrime platform as a service. Assessment results will be generated and will be returned to the platform based on process and product information.*

The service intends to prove that new products made from used raw materials will lead to **a better and greener environment.**

Outputs

For regional officers:

The service is intended to create ecological and ecological awareness and also to establish a comparison between different approaches.

For customers:

The service is intended to create ecological and ecological awareness and also to establish a comparison between different approaches.

3.4 – Demand and supply matching

Objective

The service targets companies that offer services, components or materials subject to recycling, or that are in demand for such offerings. It provides means to publish, search and select supplier offerings and demander needs for digitized auctioning and contract establishment.

Methodhology

Suppliers and demanders publish their offerings and needs, which then can be searched for to identify potential business links that can be explored further with other DigiPrime services, or through auctioning to achieve market equlibirium between these stakeholders. The stakeholders can act upon their own behalf, or rely on a third party broker for these interactions.

Outputs

For suppliers:

Matches with possible customers (demanders) of the offered services, components or materials. Established signed digitized (Ricardian) contracts representing call-offs (e.g. with price and volumes stated) towards previously established frame agreements that regulates legal aspects for the forthcoming trade.

For demanders:

Matches with possible suppliers of needed services, components or materals, captured in contracts as for the suppliers.

For brokers:

Matches between possible suppliers and demanders of services, components or materials, captured in contracts that are signed on behalf of the suppliers and/or demanders that are represented by the broker.

3.5 Sustainable reverse network configuration

Objective

The objective is to provide a reverse logistics service for remanufacturers which starts as early in the reverse supply chain as possible. Basing on a digital app, information on used parts is collected from the last usage environment of an old part. This information is shared via the DigiPrime platform for optimizing the reverse supply chain, deciding on circular usage scenario for the used parts and improving the remanufacturing production by using data out of the usage environment of the products.

Methodology

A mobile app allows to collect information on the location and condition of used parts directly from its last usage environment (e.g. automotive workshop). The digital sensors of the device and AI can be used to simplify the process for end users and make data more reliable. The digital collection of information is linked to the ability of conducting physical reverse logistics for used parts so that an optimization can be achieved and a service offer can be provided to remanufacturers.

Outputs

- *"Reverse last mile problem": Optimized reverse logistics flow of used car parts from small locations such as automotive workshops.*
- *Network planning and simulation for reverse logistics.*
- *Decision on circular usage scenario and granting of incentives possible before used part is transported.*
- *Bundling of reverse transport volumes of several product types and producers.*
- *Access to specific information on product type, condition and failure protocol out of last usage environment (e.g. error codes and testing protocol from vehicle OBD test equipment) for reman producers.*

3.6 - Cross-regional value-chain identification

Objective

Service targeted to regional governments and local stakeholders (companies and research centers) dealing with circular economy; -it provides automated identifications of possible cross-regional/cross sectorial circular value chains and circular synergies among stakeholders. More info at: www.digiprime.eu/pilots/cross-regional-value-chain/

Methodhology

Service provision is based on a series of data sheets to be filled-in by regional officers and local stakeholders and four automated mechanisms able to elaborate the data and find matchings between sectors of activities, needs of regions, companies' innovation capabilities, research capabilities, etc.

Outputs

For regional officers:

- *Dashboard with data related to circular economy in the region, automatically updated each time a new local stakeholder provides inputs.*
- *Notification of possible cross sectorial and/or cross regional circular value chains.*
- *Notification of possible solutions (through innovation or research capabilities) of regional circular economy issues*

For local stakeholders:

- *(Companies) Notification of circular economy synergies with other companies inside or outside the region; notification of possible business opportunities.*
- *(Research centres) Notification of research needed by companies or regional authorities.*

3.7 – KPI and material flow monitoring

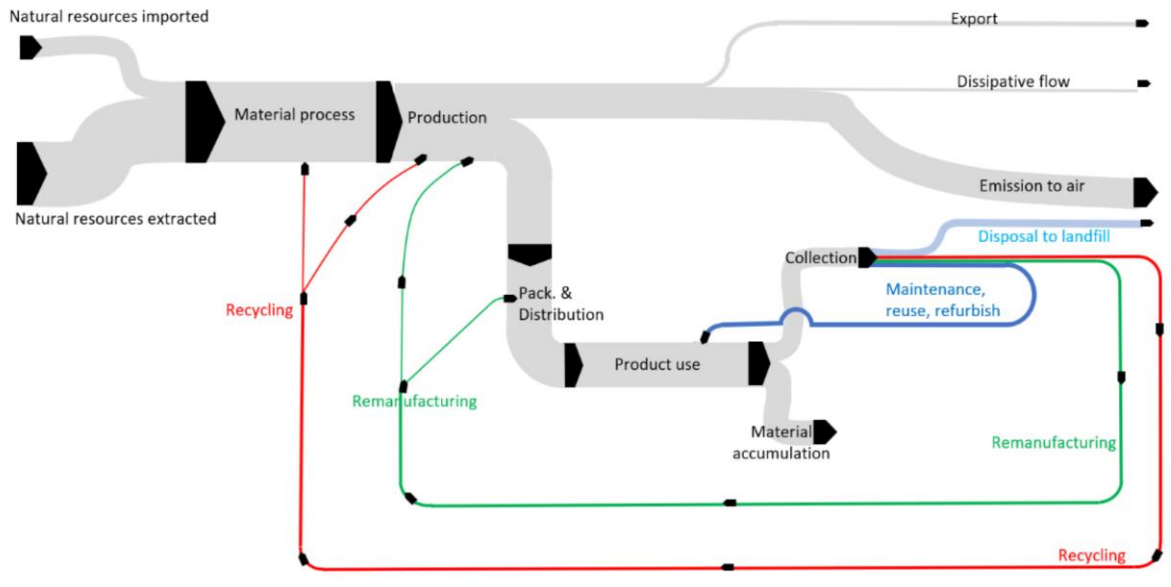
Objective

To support decision makers to define directives or new legally binding requirements to influence circular economy practices, based on the observation of the real material flows.

Methodhology

Service provision is based on designing and implementinga material flow monitoring system generating aggregated KPIs at system level, by gathering data on Companies and the "circular entities" they exchange. A Sankey diagram helps decision makers in their policies' implementation

Outputs



3.8 – Circular innovation hubs integration

Obiective

In this task, a software application specifically targeted to exploit the DigiPrime platform federation-based architecture to support the operation of distributed Circular Innovation Hubs is developed. (www.digiprime.eu/pilots/circular-innovation-hubs-integration/).

Methodology

Circular Innovation Hubs are designed as distributed pilot facilities to serve companies in multiple sectors solving sustainability-oriented problems by demonstrating innovative circular business cases and technologies, with the goal to de-risk the downstream private investments.

Outputs

In order to properly operate these networks the application developed in this task will provide capability (i) to visualise the pilot infrastructure capabilities to different sectorial node of the DigiPrime federation, (ii) to approach and offer customized support services to the registered stakeholders, thus extending the user basis, (iii) to communicate best practices and success stories throughout the pilot network operation, and to (iv) support the operational governance of these networks while including new regional hubs, and monitoring activities of the hubs.

Such distributed networks will expand in Europe and are promoted by different high-level initiatives including the Digital Innovation Hubs, and the Smart Specialisation Platforms.

3.9 – Barriers Identification and Legislation Support

Objective

Service targeted to regional governments and local stakeholders (companies, and sectoral representatives) dealing with circular economy; -it provides a collaborative and automated tool to exchange information and data about barriers hampering the transition toward a circular economy (experienced by the companies) and to cooperate toward the definition of solutions in terms of policy interventions.

Methodhology

Service provision is based on a series of input form (to be filled-in either regional officers and local stakeholders) describing -barriers, -operative solutions, -proposition of solutions, -solutions. The data collected are elaborated and sent to the targeted policy officers of displayed in the platform to ensure an efficient research process and an exchange among users.

Outputs

For regional officers:

-submit barrier to other policy makers at upper level

-submit a proposition for a solution

-communicate with local stakeholders

-solve a barrier by inserting a new policy intervention

-notification of new barrier

-notification of solved barrier

For local stakeholders:

-submit barrier to a policy maker

-submit a proposition for a solution

-communicate with other companies and with policymakers

-submit an operative solution (workaround to a barrier)

-notification of solved barrier

4.1 – Product in-use data acquisition and monitoring

Objective

The Product Avatar tool is a software solution that allows different actors to manage the information related to a real Product during its ongoing lifecycle.

The actors that interact with the Product information can have different roles and can be working in different companies.

Through the Product Avatar it is possible to search all the information already saved in the platform, related to a specific object.

Methodhology

- *create and visualize object types and attributes' types*
- *describe an object with flexible attributes and parameters related to the usage phase of it*
- *record the information related to a specific product while in use*
- *manage different actors' roles*
- *search among objects and attributes*

Outputs

Keeping record of the information related to the things that happens to an object during its period of life.

Keeping track of the previous lifecycles of an object.

4.2 – Product Condition Prediction AI algorithms

Objective

The Product Condition Prediction service aims to support the de- and remanufacturing processes by providing immediate condition prognosis for second-life products, thus aiding circular economy. The main functionality of the service is to provide a catalog of predefined models in order to predict different properties related to the product condition in different stages of the product's lifetime.

Methodology

The models of the catalog are built utilizing Machine Learning and other AI algorithms. Each model solves a prediction scenario in a form of inputs and outputs, which describe the source information (input properties like product specification, test results, in-use history data) and the prediction target (output properties indicating the product condition).

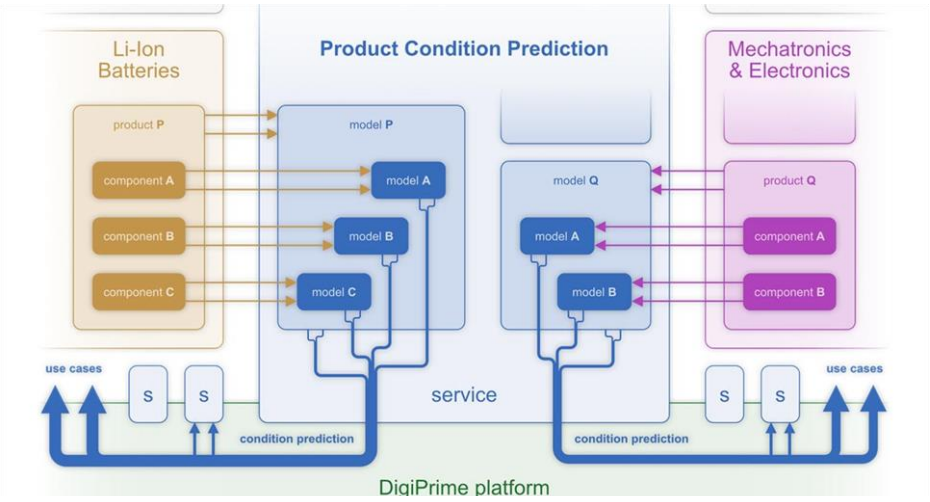
Outputs

<u>For the user</u>:

- *Product condition indicators (like State of Health) for the provided second-life products, considering the input requirements of available models*
- *Display and file export options of the predicted product condition indicators*

<u>For the platform</u>:

- *Optional upload functionality for the predicted product condition indicators, expanding the available information on the products*



4.3 – De and remanufacturing Decision Support System

4.3.1 -Decision Support System for Composite Recycling (DSS4CR)

Objective

The service is targeted to stakeholders (companies) dealing with post -use product conditions; the service applies decision algorithms and to define the best circular economy strategy for the products that return for post – use in the shop floors.

Methodhology

The service is based on the data provided by the shop floors or other services in the DigiPrime ecosystem. These data describe the condition of the product during the return phase and the processes followed. The service is able to combine all these data and comes with an output concerning the best circular economy strategy to be implemented, i.e. rework, repair, recycle.

Outputs

The service outputs for the stakeholders include:

- *Notification of the circular economy strategy implemented to the returned product so it returns to the most efficient position inside the CE strategies*
- *Notification of the scenario results tested based on the incoming data for the same return products.*
- *Reports on the results of different circular economy strategies implemented for the same returned product create by combining multiple scenarios*

4.3.2 -Decision Support System for Composite Recycling (DSS4CR)

Objective

Service targeted to regional and local stakeholders (mainly companies) dealing with circular economy (Waste managers, recyclers manufacturers and waste generators); it provides automated identifications of possible treatments, processes and post-processes for each plastics and composites waste typology.

Methodhology

Service provision is based on 2 algorithms that weight and correlate input data (decision criteria) and output options (most appropriate treatments). The algorithms are designed by applying the "Decision Matrices". The input data are entered by any of the potential users and refer to the characteristics of the waste and the position of the stakeholders in the value chain.

Outputs

For regional and local manufacturing companie:

1. Demanufacturing processes selector Modul outputs

They select the best option from the following possibilities:

- *Reuse*
- *Remanufacture*
- *Recycling*
- *Energy valorization*
- *Disposal*
-

2. Recycling processes selector modul outputs

They select the best option from the following possibilities:

- *Waste Manager*
- *Systems demounting / parts sales*
- *Dismantiller /Sorting, cleaning*
- *Thermal process recycler: Pirolysis or Combustion*
- *Fiber Conditioner /cutting, sizing, etc.*
- *Textil processes*
- *Compounder /Semi- finishing maker: Thermoplastics, Thermosets or Both /Indiferent*
- *End user o parts supplier*

4.4 Digital Twin for de-and remanufaturing

4.4.1 – Digital Twin based Simulation

Objective

Digital Twin to support de/remanufacturing operators to adapt their processing strategy depending on the conditions of their system and the conditions of the return post-use products.

Methodhology

Validation of the production plan based on the DT-enabled awareness of the complex system interaction and actual shopfloor status.

What-if analysis to evaluate different optimization and reconfiguration scenario.

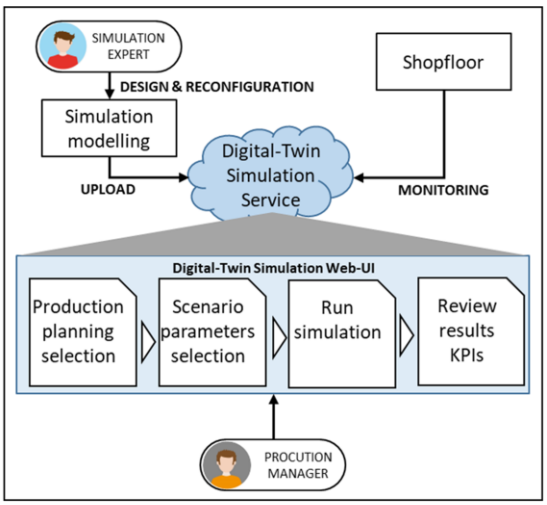
Outputs

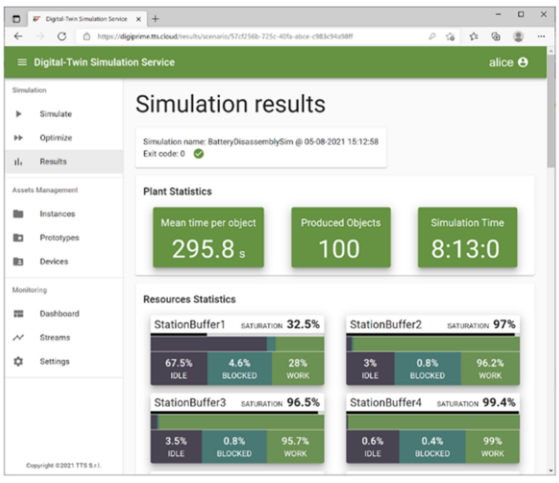
<u>Production planning / scheduler validation:</u>

- *Validation of the scheduler output (production plan) based on a more detailed awareness of the production process status that can take into consideration the actual shopfloor status.*
- *Pre-emptive evaluation of the probability to meet the expected delivery date.*

<u>Design and reconfiguration</u>

- *Support for the detection of critical bottlenecks, also in planned/simulated workload.*
- *Evaluation of different scenario (how the introduction of a parallelization or change of process may affect the overall plant performance).*





4.4.2 - Digital Twin simulation of compounding process for parameter optimization

Objective

Service targeted to regional and local stakeholders (mainly companies) involved in the compounding and formulation of plastic materials, providing information on the processing of recycled reinforced materials.

Methodhology

The provision of services is based on the analysis of a large amount of experimental data for the processing and obtaining of recycled fibre reinforced compound material for subsequent use in plastic injection moulding processes. Several types of data are analysed: data concerning the characteristics of the raw materials data obtained on-line during processing on the extrusion machine and data obtained from the analysis and testing of the material obtained.

Outputs

The service allows the user to select the right raw materials and to predict the processing parameters when a material KPI must be met for a specific plastic injection moulding application.

INPUTS: final material KPI (mechanical properties)

OUTPUTS:

- *Materials:*
  - *Type of matrix*
  - *Type of recycle fiber*
  - *% and length of recycled fiber*
- *Process parameters:*
  - *Temperature*
  - *Dosing rate*
  - *Extrusión speed*

4.4.3 – Digital Twin Value Stream Simulation

Objective

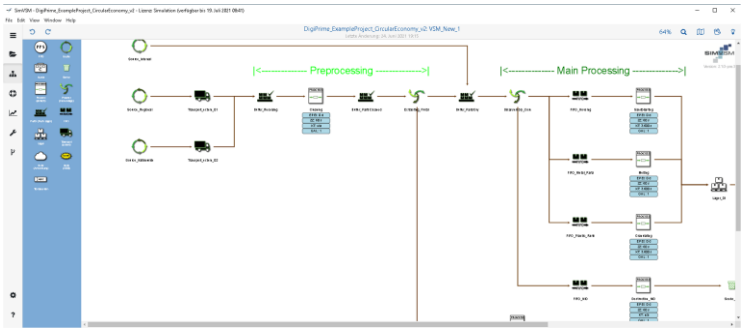
The service enables the user to use the lean management method of value stream mapping in the context of circular economy processes. The functionalities range from digitization and documentation to simulation of the value stream.

Methodology

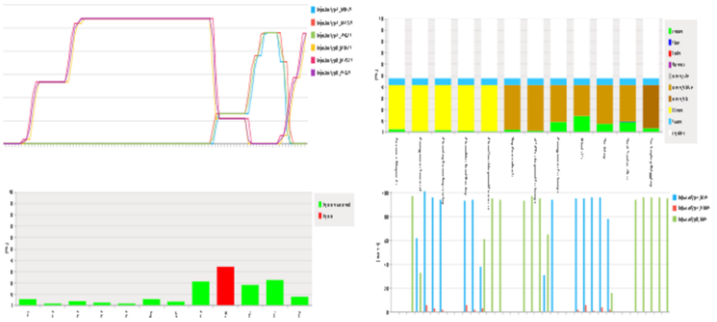
The library of the classic value stream objects will be extended by adding components to also cover the specific processes of the circular economy e.g. disassembly, quality grading and reconditioning. Settings such as the BOM/Reverse BOM are taken over directly from the DigiPrime platform.

Outputs

Visualization and digitized documentation of a value stream with static KPIs:



Standardized report of simulation results:



4.5 –Supply and Demand Forecasting

Objective

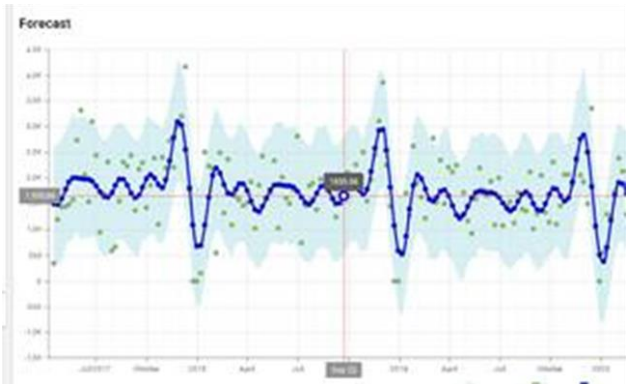
Service to forecast the demand for (remanufactured) products and the supply of (post-)products using data from the past. Application scenarios are the support of medium-term production planning or long-term capacity planning.

Methodology

The services make use of statistical methods, e.g. time series analysis, regression analysis, and seasonal factors and it implements available state-of-the-art approaches such as facebook's prophet model. The user may select the forecast method of his/her choice.

Outputs

Visualization of historic data and of forecast



Forecast information as time series data in spreadsheet or database format

4.6 – Circular Production Planning and Control

Objective

The service supports production scheduling in circular value-chains. Additionally, the service includes a Reverse Bill of Material (BoM) Explosion logic to identify the right cores to be used in remanufacturing.

Methodhology

The Reverse BoM Explosion ensures that the selected cores meet the demands of the final assembly as well as possible. The scheduling considers the sequence of processes for a core, the capacities and the capabilities of the resources and the BoM of the final products and has the objective to calculate the shortest make span possible for the complete remanufacturing process.

Outputs

The result of the Reverse BoM is a list of cores that are to be used for remanufacturing at the relevant period in time.

The result of the scheduling is a detailed schedule for the remanufacturing saying exactly which process for which core or which product has to be performed at which time on which resource.

4.7 – Material testing and certification

Objective

To provide information about tests and certifications that can be used and applied for/to specific materials and products with the aim to improve the knowledge of their properties and performance. This will support materials and products second-life use through recycle and reuse.

Methodology

Service functionalities start from inputs in form of keywords that describe materials and products. Service processes these inputs to find match with internal database then providing outputs as tests and certifications list specific for the material/product. Additional information can be provided as output in order to facilitate users with testing and certification activities.

Outputs

Service provides outputs in form of test and certification lists related to materials and products. These outputs can be used by different stakeholders in order to boost circularity.

Dismantlers/retailers: tests and certifications can help them to assess materials residual performances to decide if products can be reused or it is better send them for recycling.

Remanufacturers: test and certifications can help them to identify the best remanufacturing processes and the best possible second life on the base of materials properties.

9.3 Description of the DigiPrime Pilots

9.3.1 Pilot 1 Battery

Problem description

Battery Pilot will aim at demonstrating that the DigiPrime platform can unlock a sustainable business case targeting the remanufacturing and re-use of second life Li-Ion battery cells with a cross-sectorial approach linking the e-mobility sector and the renewable energy sector, specifically focusing on solar and wind energy applications.

Challenges

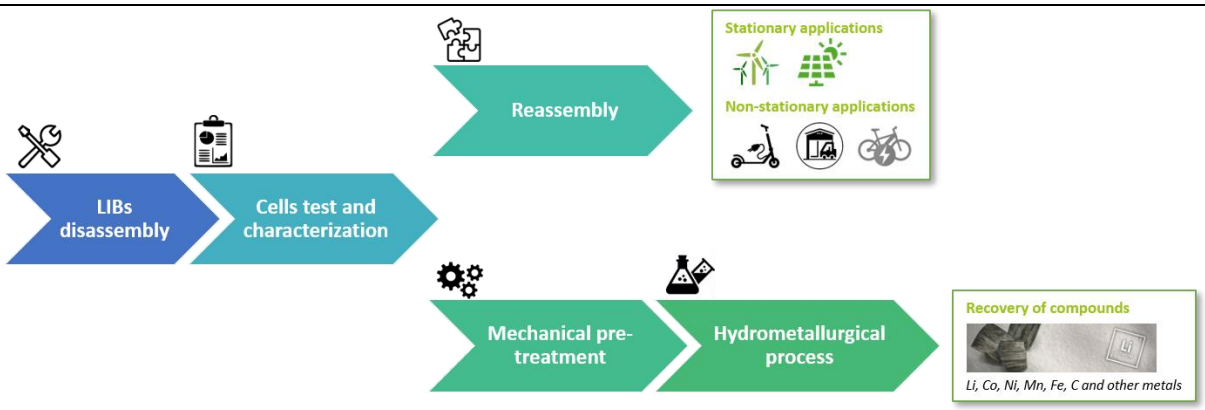
The battery pack is the most important component of a hybrid and full electric vehicle (H&EV), making up more than one third of the cost of the vehicle itself. Unavoidable chemical and physical degradation of the cells forces battery packs to a performance fade over time. EVs battery packs have an average lifespan of 8 to 10 years, during which their actual capacity degrades below the 80% of the initial capacity, requiring pack substitution. Packs which are not anymore suitable for traction purposes preserve high value, since ageing and failure of cells is an uncertain process and in post-use modules both strongly compromised cells as well as poorly degraded cells are found. Therefore, some cells/modules would still feature suitable residual performance to be re-used, after characterization, in less-demanding second-life stationary application, as Energy Storage Systems (ESS). However, the cost of new Li-Ion batteries prevents from implementing this solution at large scale. This is a currently untapped opportunity for an innovative circular economy business case that will be demonstrated within this pilot.

Overall approach

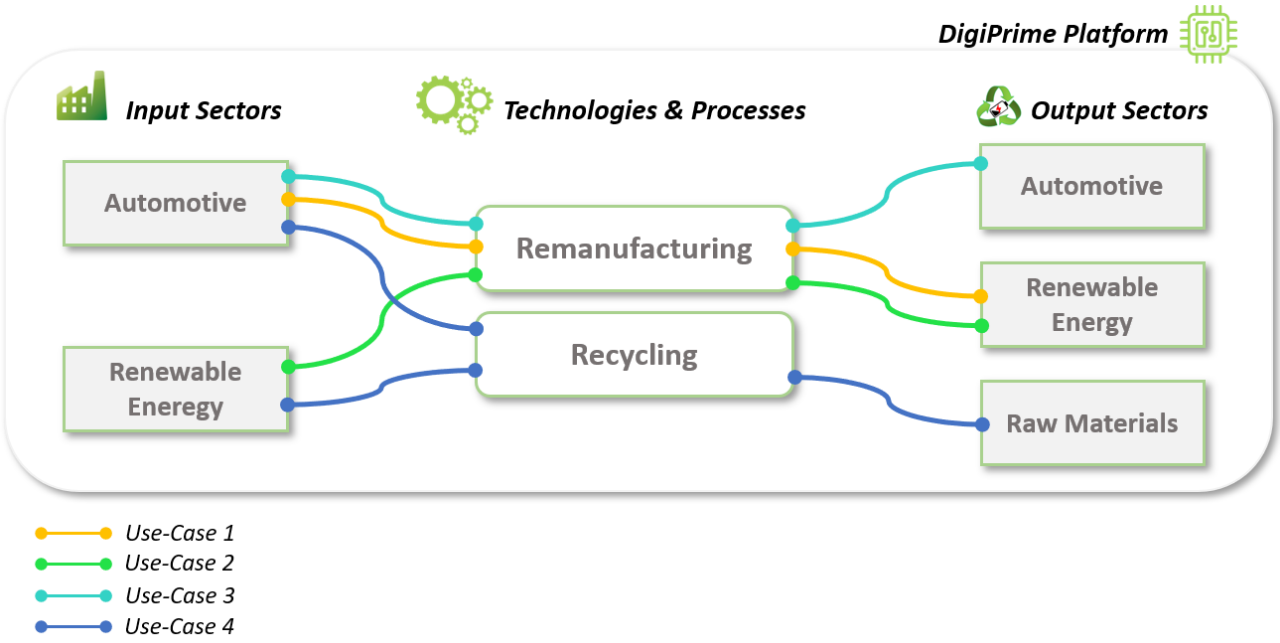
For its high remaining value, both in terms of availability of precious and critical raw materials (as lithium and cobalt), several solutions have been investigated to preserve post-use Li-Ion battery value. The two most common approaches are:

- Open loop recycling: to apply pyro-metallurgical processes for cobalt (and rarely lithium) recycling;
- Direct re-use of battery packs: to directly reuse the battery pack in for stationary applications.

However, the lack of information sharing and of a structured reverse logistics value chain causes a dramatic value drop in the currently exploited circular economy strategies. In fact, the second-life strategy for a battery pack is decided mainly in function of its State-Of-Health (SOH), constantly monitored during the use phase by the Battery Management System (BMS). However, these data are currently unexploited and expensive testing procedures have to be performed to estimate Li-Ion battery cells/modules SOH. The availability of in-use data would support faster prediction of battery cells state-of-heath and reduce the characterization costs. Moreover, managing data on the battery pack configuration would make it possible to perform non-destructive de- and remanufacturing processes and deliver to the customer a battery quality certification, increasing the added-value of the second life applications.



Use-cases and involved sectors (input and output sectors)



Use-case 1

CE Strategy: Remanufacturing

Input Sector: Automotive

Output Sector: Renewable energy

Use-case 2

CE Strategy: Remanufacturing

Input Sector: Renewable energy

Output Sector: Renewable energy

Use-case 3

CE Strategy: Remanufacturing

Input Sector: Automotive

Output Sector: Automotive

Use-case 4

CE Strategy: Recycling

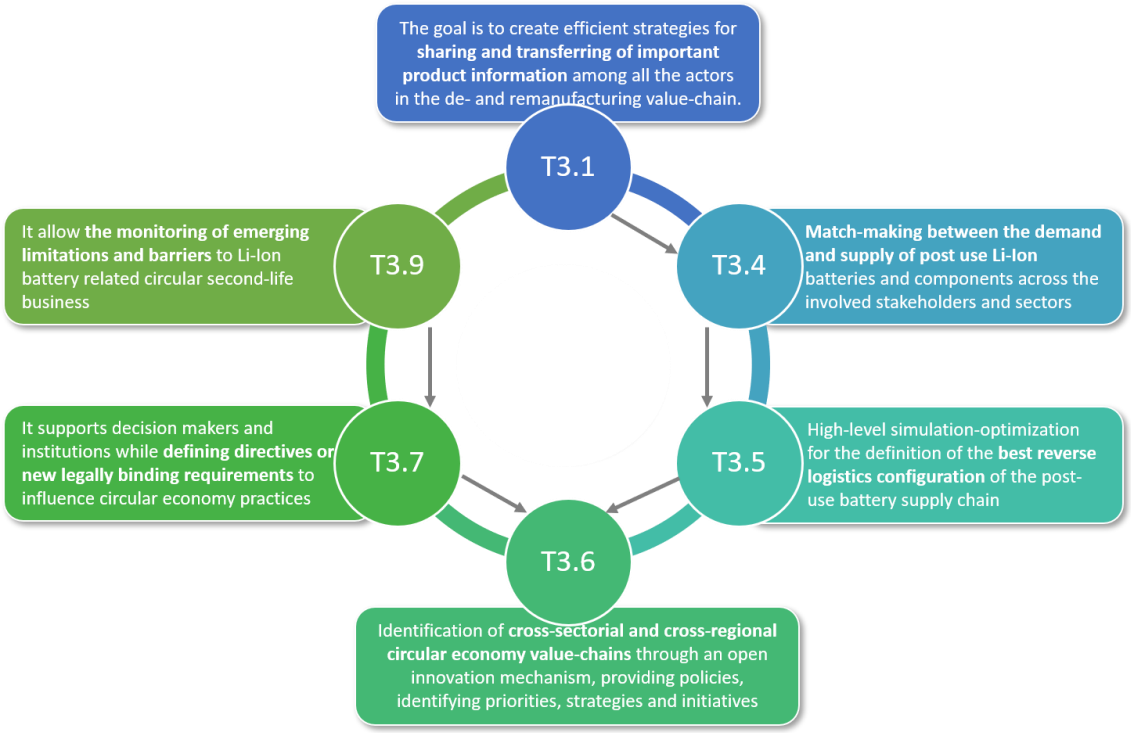
Input Sector: Automotive, Renewable energy

Output Sector: Raw materials

Involved DigiPrime services

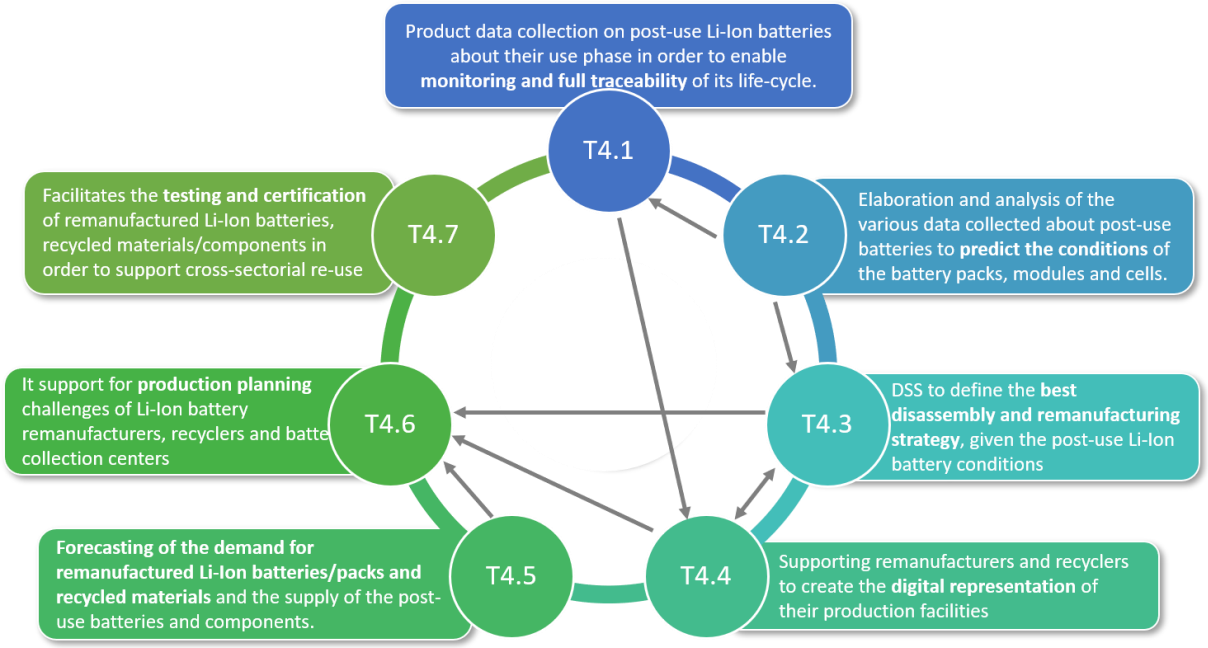
The most relevant value-chain oriented services aim to:

- product information management and data collection on post-use Li-Ion batteries about their use phase in order to enable monitoring and full traceability of its life-cycle;
- define a sustainable value network and reverse logistics configuration of the post-use battery supply chain;
- monitoring of emerging limitations and barriers to Li-Ion battery related circular second-life business.



The most relevant operational services aim to:

- collect product data on post-use Li-Ion batteries about their use phase in order to enable monitoring and full traceability of its life-cycle;
- elaborate and analyse various data collected about post-use batteries to predict the conditions of the battery packs, modules and cells;
- define a Decision Support System to identify the best disassembly and remanufacturing strategy, given the post-use Li-Ion battery conditions.



Detailed description of the approach

As the proactive exploitation of the DigiPrime platform enables the car-monitored SOH tracing and availability, less testing is needed to assess the residual capacity of the battery. Moreover, by knowing the structure of the battery packs, a decision support system can be implemented to adjust the de-and remanufacturing strategy accordingly and select the most proper cells for re-assembly second-life modules, thus unlocking a systematic circular value chain for Li-ion battery cells re-use. Furthermore, excessively degraded cells which cannot be re-used can be sent to high-value recycling, based on the knowledge of their material compositions.

9.3.2 Pilot 2 Mechatronics and Electronics

Problem description

Nowadays remanufacturers in the automotive and commercial vehicle industry are facing a lack of planning reliability. Due to fluctuating core return rates and changing core quality it is difficult for remanufacturers to predict the inbound cores (used parts) and thus the planning of the production and further supply chain.

Pilot 2 enables a platform for repair manufacturers for reusing obsolete electronic components resulting in an increased overall regeneration rate and reduced landfill.

Challenges

Increasing the overall regeneration rate concerns the complete process from exchanging the part at the workshop till the reassembly of the remanufactured components. Different parties (e.g. workshops, core selection stations, etc.) within this process need to exchange information. Achieving this requires an early stage sorting in the value chain by developing suitable incentives.

Overall approach (focus on innovation sources)

This task will demonstrate that the DigiPrime platform can improve the performance of the current business case targeting the remanufacturing and re-use of complex mechatronics and electronics components for aftermarket applications with a cross-sectorial approach linking the e-mobility and the smart machining systems sectors, specifically focusing on breaking systems, e-drives and Printed Circuit Boards (PCBs). The business case will entail the following process steps:

Disassembly of the modules exploiting product information, testing and characterization of the components conditions depending on gathered use phase data, selection of re-usable modules, substitution of non-re-usable modules, remanufacturing for function restore (cleaning, machining, inspection, painting/coating), re-assembly and performance certification. Four use cases will be explicitly demonstrated within this pilot, connecting the targeted sectors with different input-output links.

Use-cases and involved sectors (input and output sectors)

Use case 1

CE strategy: Remanufacturing

Input sector: Automotive

Output sector: Automotive

Use case 2

CE strategy: Remanufacturing

Input sector: Automotive

Output sector: Automotive

Use case 3

CE strategy: Remanufacturing

Input sector: Automotive

Output sector: Automotive

Use case 4

CE strategy: Remanufacturing/Repair

Input sector: Automotive and electronic industry

Output sector: Automotive and electronic industry

Involved DigiPrime services

The most relevant value-chain oriented services aim to:

- Define the best reverse logistics configuration in order to maximize the economic and environmental performance of the cross-sectorial value-chain.
- Forecasting the demand for remanufactured products and the supply of post-products in order to support de- and remanufacturers in their production planning and long-term capacity allocation.
- Support production planning and control in circular value-chains, able to match the value stream of the production system with the de- and remanufacturing system implications.

The most relevant operational services aim to:

- Support the optimization of reverse logistics configuration based on economic and environmental performance indicators.
- Predict the expected quantity and quality of returned products and their components by using the actual data of returning products.
- Provide strategically planning recommendations for the remanufacturing- and new product-production.

Detailed description of the approach

First, a constantly high and predictable supply of old products (cores), must be ensured. Thus, a higher core return rate can be achieved, which saves resources and increases the viability of circular strategies. To achieve this, information sharing across stakeholders of the value chain as well as incentives for customers and workshops to return cores must be assured.

Secondly, these information and data from different stakeholders along the value-chain can be used to increase the planning accuracy of remanufacturing or repair processes. Nowadays, much information is not being gathered or lost along the value-chain which are considered to be useful for a more specific and plannable remanufacturing value chain.

Thirdly, demand planning of remanufactured components versus newly manufactured components relies on accurate and precise information. Moreover, it is required to produce “fake” remanufacturing products (meaning to sell original products but label them as ‘remanufactured’) due to a higher demand of

remanufactured products on the market and the insufficient supply of cores. Pilot 2 will focus on improving the core return on European level as well as the data collection to improve the demand planning, which also poses a significant challenge.

Fourthly, obsolete components, which cannot be supplied anymore, remain a challenge to increase the re-usage rate of cores. Especially when it comes to electronic and electrical components, an information exchange between stakeholders of the value chain as well as cross-sectorial information exchange could reduce the scrap rate.

9.3.3 Pilot 3 Composites and Techno-polymers Pilot Summary

Problem description

The composites and techno-polymers pilot will demonstrate that the DigiPrime platform can unlock a sustainable business case targeting the recovery and reuse of composites (CFRP-Carbon Fiber Reinforced Plastic and GFRP-Glass Fiber Reinforced Plastic) and both thermoplastic and thermoset polymers (PA, PC, PBT, PP, ABS, UP, PU, …) with a cross-sectorial approach linking the automotive, the construction, the renewable energy, and the design sectors.

Current waste management practices in thermoset composites are dominated by landfilling which is still a relatively cheap option but doesn't comply with the Waste Framework Directive (2008/98/EC); while thermoplastic composites already have recycling and material recovery chains.

Challenges

The demand for GFRP and CFRP as lightweight functional components for the automotive and aeronautical industry grew steadily over the last years. Furthermore, the continuous expansion of the use of renewable energy sources, especially the intensified utilization of wind power plants, has further increased the need for GFRPs and CFRPs. The mobility sector (including automotive, locomotive and aeronautical) as well as the construction and infrastructure sector (including wind energy) each consume approximately one third of the European GFRP production. Similar trends are observed in the global consumption of CFRP, particularly in aeronautical, automotive and wind energy applications.

Composites components from these industrial sectors have relatively long life cycles, which complicates the localization of end-of-life waste.

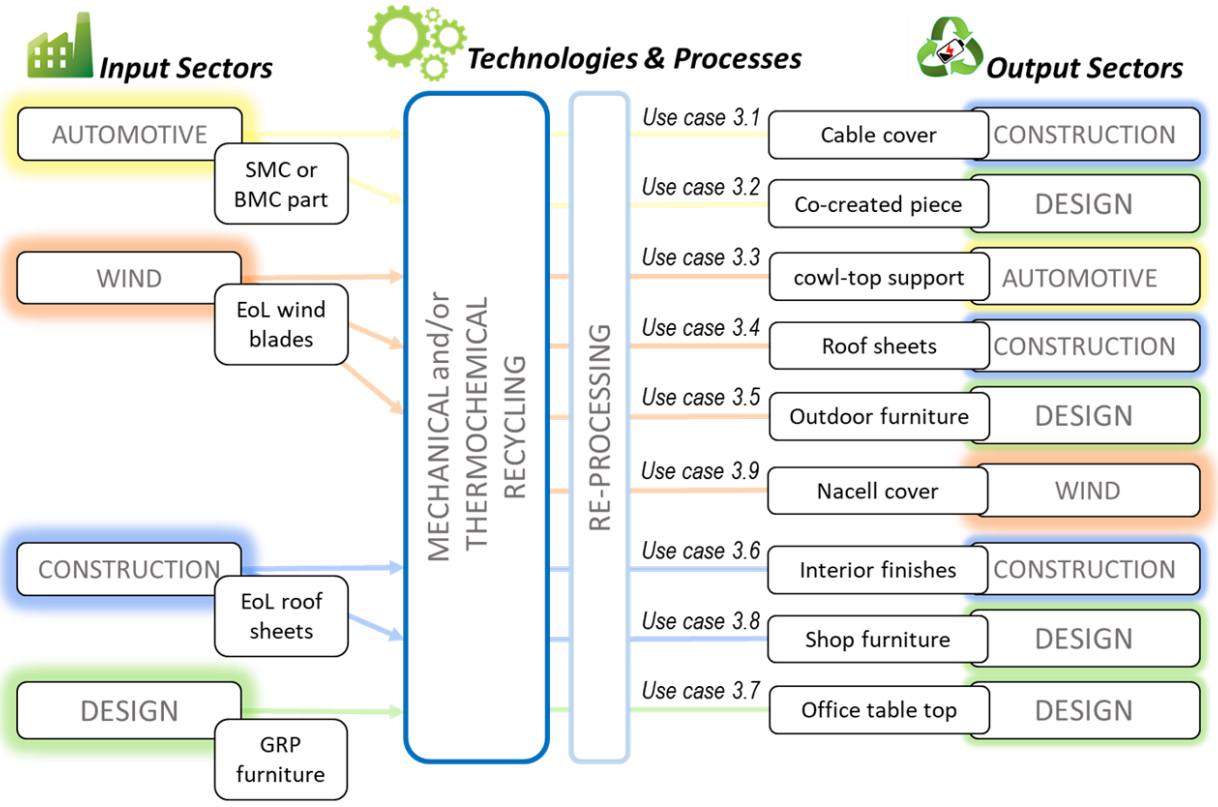
Overall approach

Composite materials can be recycled following mainly three family of processes:

- Mechanical, aiming at directly reuse the material after size reduction processes
- Thermal, through which, increasing the temperature in a controlled environment, is it possible to obtain clean fibers
- Chemical, able to dissolve the resin matrix through solvents leaving clean fibers

Even if a degradation of mechanical and physical properties appears after each of these processes, the implementation of a cross-sectorial approach allows to reuse recycled materials in high-added value products. in this context, the role of data is fundamental to overcome several issues as the lack of information sharing, the demand and supply matching, the scarcity of testing and verification protocols and the heterogeneity in legislation at different levels, from regional to European.

Use-cases and involved sectors



Use-case 1

- CE Strategy: Recycling/Reprocessing
- Input Sector: Automotive
- Output Sector: Construction

Use-case 2

- CE Strategy: Recycling/Reprocessing
- Input Sector: Automotive
- Output Sector: Design

Use-case 3

- CE Strategy: Recycling/Reprocessing
- Input Sector: Wind
- Output Sector: Automotive

Use-case 4

- CE Strategy: Recycling/Reprocessing
- Input Sector: Wind
- Output Sector: Construction

Use-case 5

- CE Strategy: Recycling/Reprocessing
- Input Sector: Wind
- Output Sector: Design

Use-case 6

- CE Strategy: Recycling/Reprocessing
- Input Sector: Construction
- Output Sector: Construction

Use-case 7

- CE Strategy: Recycling/Reprocessing
- Input Sector: Design
- Output Sector: Design

Use-case 8

- CE Strategy: Recycling/Reprocessing
- Input Sector: Construction
- Output Sector: Design

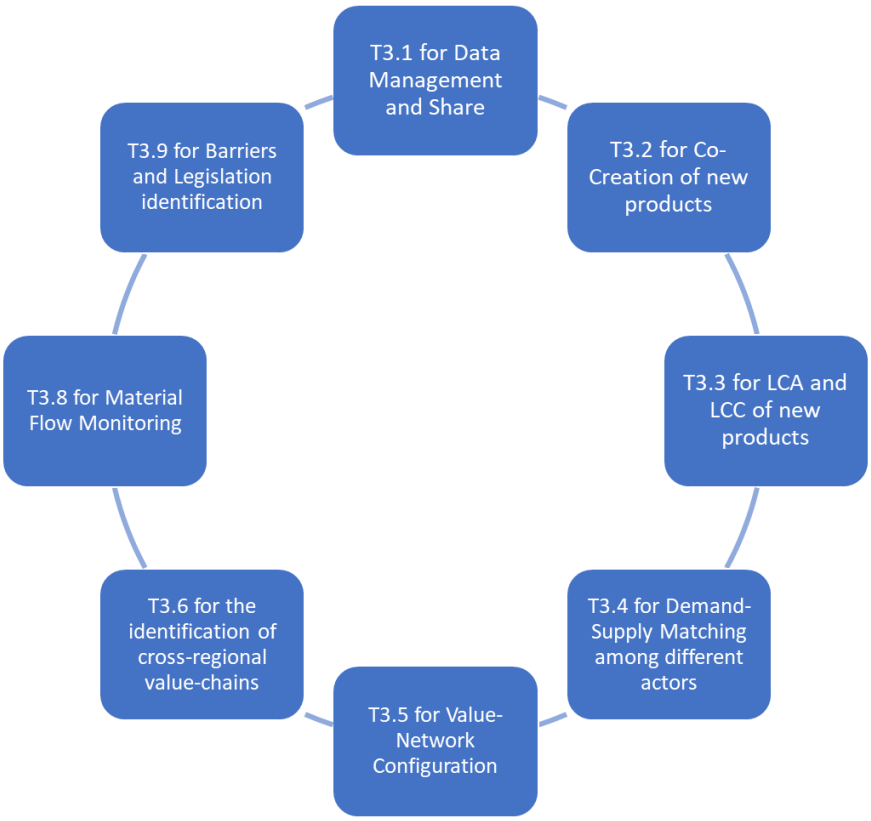
Use-case 9

- CE Strategy: Recycling/Reprocessing
- Input Sector: Wind
- Output Sector: Wind

Involved DigiPrime services

The most relevant value-chain oriented services for Composites and Techno-polymers Pilot aim to:

- Support the design and production phases of new products embedding recycled material
- Facilitate the matching between demand and supply of End-of-Life products and materials
- Establish robust circular value-chains in composites sector
- Facilitate the adoption of products embedding recycled material



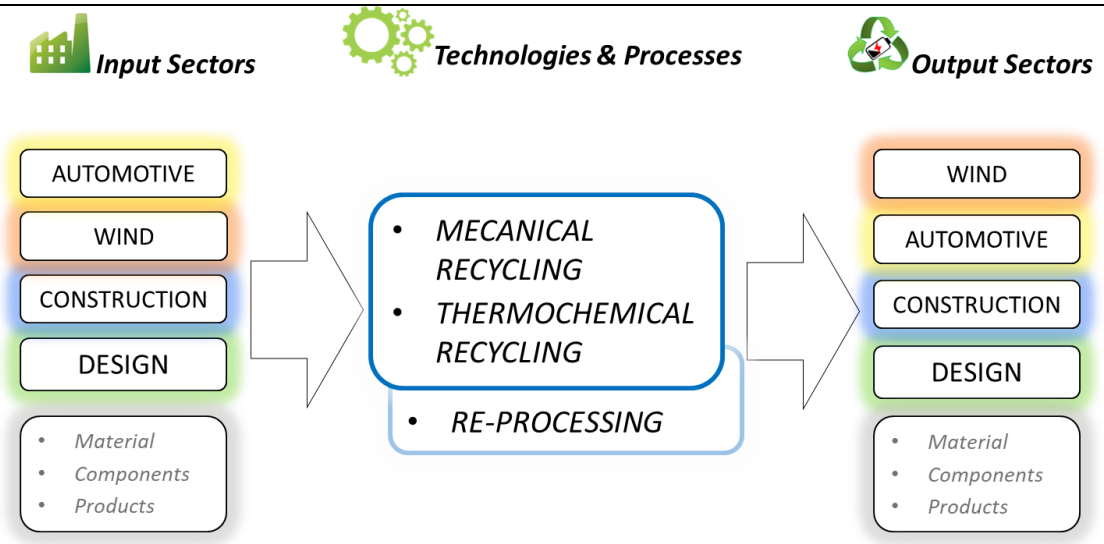
The most relevant operational services for Composites and Techno-polymers Pilot aim to:

- Define a Decision Support System to identify the best disassembly and demanufacturing strategy
- Continuously support the established circular value-chains
- Favor the adoption of well-defined testing and certification protocols

Specific description of the approach

Through the exploitation of the DigiPrime platform, the Composites and Techno-polymers Pilot will demonstrate the possibility to establish robust and well-defined circular value-chains in different sectors, demonstrating the power of the cross-sectorial approach and favoring the multiplication of the adopted solutions. Exploiting all the identified services, the pilot will develop several demonstrators mainly in automotive, wind energy, construction and design sectors through the use of both mechanical and thermal recycling.

The overall approach of the DigiPrime platform in the composites sector, is to define a complete value chain starting from the End of Service of a specific product to a new, recycled or embedding recycled material, product. Along the value chain the platform figures out all the actors and stakeholder necessary to let the material flows and the business start. Digital services are developed for each actor along the process chain to help and support the specific activities of the actor/company itself.



KPIs

- 90% recovery rate in the cross-sectorial reuse of materials;
- 40% recycled fiber content embedded in new products;
- 85% energy savings compared to virgin fibers production.

9.3.4 Pilot 4 Textile parts

Problem description

The objective of this pilot is to demonstrate the fundamental role of the DigiPrime platform to support the creation of a robust circular economy for textile-made components through a cross-sectorial approach between automotive (especially for interior trim) and other textile sectors (e.g., furniture, technical textiles, etc.). Currently, a large part of textile components is not removed from end-of-life vehicles before their demolition, so it ends in the automotive shredded residue (ASR) with a consequent loss in its potential valorisation. To improve textile materials circularity, the pilot aims to fulfil the information gap between the different actors and steps of the textile supply chain in automotive and other sectors.

Challenges

Textiles are essential parts of cars and other vehicles as they provide a warm and soft touch to surfaces but they also are components of the more functional parts of vehicles. Traditional use of textiles in automotive includes interior fabrics, seat upholstery, carpets, and headliners but textiles are also used to realise tire cord, fuel filters, safety belts, heater hoses, battery separators, break and clutch linings, gaskets, air bags and as reinforcement for composites. Automotive textiles have an estimated lifetime that is the same as that of the vehicle (12 years) and at the end of the vehicle life, textiles are not usually dismounted and removed but they become part of the automotive shredded residue. This current practice comes from the lack of specific and consolidated information (data, procedures, best practices) about dismounting and removal of textile parts, about verification of their quality and performance and about how to remanufacture or recycle them to create new products. By implementing DigiPrime approach (using platform's services), Textile Pilot will demonstrate the possibility to create a virtuous circular system for textile reuse/recycle/remanufacturing between automotive and other sectors.

Overall approach

Considering the large amount of different textile and textile-based materials that come from automotive sector (over 15-20 different kinds of fabric are used in automobiles), specific categories are considered for the pilot preliminary evaluation: seat upholstery and padding, carpets, headliners, safety belts and air bags.

The overall approach of this pilot is to reduce the information gap among textile industries, automotive industries, and other possible production sectors. This aim will be reached through specific activities:

- to identify specific composition of the main automotive textile waste (ATW) coming from vehicles dismantled at their end-of-life;
- to characterise ATW in terms of properties (mechanical, chemical, ecological, etc.);
- to define and test ATW dismantling procedures and subsequent material separation and sorting;
- to define and test recovery, reuse and recycle practices for ATW;
- to select and validate cross-sectoral applications for ATW.

Use-cases and involved sectors (input and output sectors)

Use-case 1

CE Strategy: Remanufacturing/recycling

Input Sector: Automotive

Output Sector: Other Textile Sectors

Use-case 2

CE Strategy: Remanufacturing/recycling

Input Sector: Other Textile Sectors

Output Sector: AutomotiveUse-case 3

CE Strategy: Remanufacturing/recycling

Input Sector: Automotive

Output Sector: Automotive

Use-case 4

CE Strategy: Remanufacturing/recycling

Input Sector: Other Textile Sectors

Output Sector: Other Textile Sectors

Involved DigiPrime services

The most relevant value-chain oriented services for Textile Pilot aim to:

- trigger demand-supply matching to monitor the flow of necessary materials in terms of what is available on and what is requested by the market;
- identify potential barriers identification and get legislation support to know and deal with the correct legislation thus implementing an effective circular business;
- assess the environmental impacts of the new circular production models.

The most relevant operational services for Textile Pilot aim to:

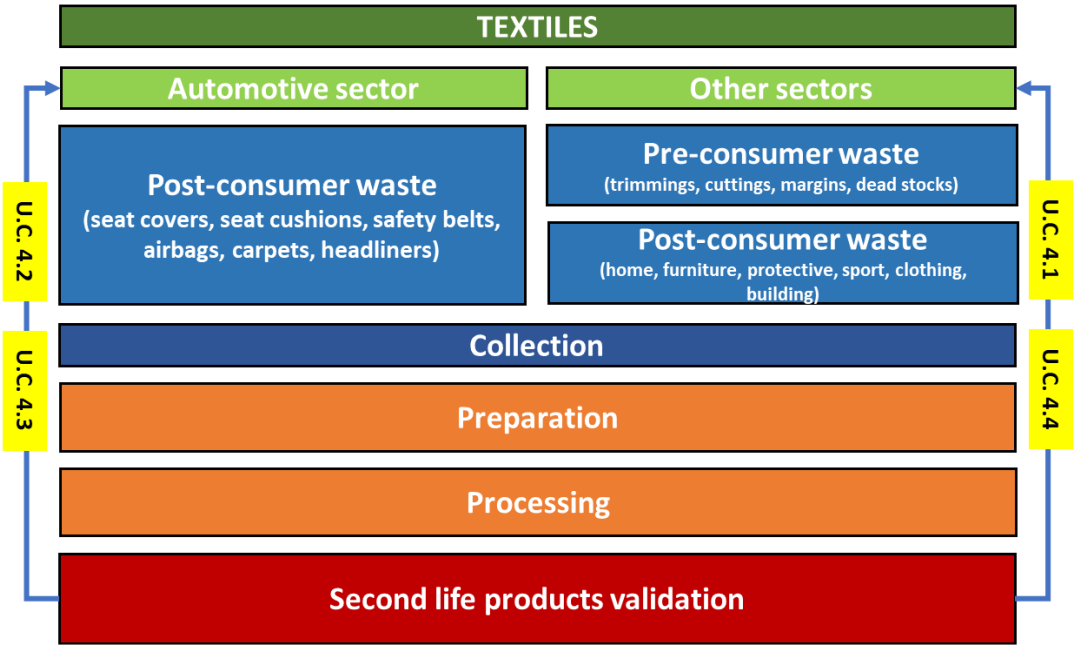
- identify the best way for de-manufacturing and remanufacturing of textile components to implement the most effective solution for their re-use or recycle;
- support the procedures to test and certificate textile materials with the aim to verify their performance and their compliance with markets requirements.

Detailed description of the approach

The knowledge of automotive textiles material coming from end-of-life vehicle (in terms of properties, residual performances and technical specifications) will be fundamental to understand how valorise them through the best recycling/remanufacturing approach. Since specific and consolidated dismounting and recovery practices for automotive textiles are not currently available, during the Pilot will be necessary to

define and validate them and to verify potential barriers for introducing textile materials (that are usually considered as low value waste) in a circular economy model. Identification of the best potential second life scenarios for automotive textile materials will be a key aspect and will be made on the base of materials characteristics and of markets needs and availability.

Images and schemas



9.3.5 Pilot 5 Cross-regional value-chain identification and open innovation

Problem description

European Regions play a fundamental role in boosting the transition towards sustainable cross-regional and cross-sectorial value networks. Circular Economy opportunities emerge from systemically connecting stakeholders within innovative value-chains that intersect the traditionally defined business sectors. Moreover, these opportunities require multi-disciplinary technical approaches that go beyond the competences on individual business actors. By exploring the existing synergies between the local smart specialization areas and core business sectors, European Regions can drive the identification and establishment of innovative circular value-chains in Europe, providing benefits to the local stakeholders and, in turn, to the socio-economical regional eco-system. However, the key issue for regional authorities and local stakeholders is not the willingness or capacity of exploiting circular synergies, but rather extracting a complete overview of their circularity situation and potential and keep up to date with identified synergies between various actors. An accessible and easy managed digital tool is needed to upscale the efficiency and coordination of the identification of cross-regional and cross-sectorial value-chains. The DigiPrime platform offers this solutions for all actors involved in a circular value-chain. Based on the methodology of the SCREEN project, the pilot 5 demonstrates the solution of exploiting a replicable and scalable approach suitable for an interregional framework. The integration of the SCREEN methodology into a digital platform, unlocks and boosts the transition for regional stakeholders to explore existing synergies and identifying new ones.

Challenges

This pilot aims at demonstrating the benefits of a new systematic approach for identifying cross-regional, cross-sectorial value chains in Europe, that could upscale into promising business cases to be operationally supported by the DigiPrime platform. In this pilot, the capabilities of the DigiPrime platform are exploited for achieving a systematic implementation of the methodology developed in the SCREEN H2020 project. 25 European Regions and 150 stakeholders are expected to be involved in the pilot, leading to 50 cross regional/cross sectorial value chains identified

Overall approach

The human-driven procedure able to identify cross-sectorial and cross-regional circular economy value-chains was co-created by 17 European regions within the H2020 SCREEN project. The procedure has been translated into an automated service able to be inserted in a digital platform overcoming current information asymmetry among value-chain stakeholders. The open innovation approach adopted for the translation enables local companies to directly insert their data and to be directly notified about circular business opportunities. The advantage of the automated identification mechanism consists in avoiding the support of a circular economy expert for the first identification of value chains and synergies matching, thus leaving the regional officer more freedom; the lower accuracy of the automated mechanisms will be compensated by the large number of data that will be available once the DigiPrime platform will be fully operating.

Use-cases and involved sectors

Use case demonstration for Pilot 5 targets the involvement of at least 25 regions in the mapping process and at least 150 local stakeholders, involving companies and research centers. They will together identify at least 50 cross-regional, cross-sectorial value-chains representing promising circular economy business cases.

Involved DigiPrime services

Pilot 5 offers four Value Chain Oriented services, each providing different approach and covers different aspects of identifying existing circularity measures and its potential. The four services are:

- **3.6 Cross regional value chain identification**
  Service targeted to regional governments and local stakeholders (companies and research centers) dealing with circular economy; it provides automated identifications of possible cross-regional/cross sectorial circular value chains and circular synergies among stakeholders.
- **3.7 Material flow monitoring and aggregated system oriented KPIs**
  To support decision makers to define directives or new legally binding requirements to influence circular economy practices, based on the observation of the real material flows.
- **3.8 Circular Innovation Hubs Integration**
  A software application is developed specifically targeted to exploit the DigiPrime platform federation-based architecture to support the operation of distributed Circular Innovation Hubs
- **3.9 Barrier Identification and Legislation support**
  Service targeted to regional governments and local stakeholders (companies, and sectoral representatives) dealing with circular economy. It provides a collaborative and automated tool to exchange information and data about barriers hampering the transition toward a circular economy (experienced by the companies) and to cooperate toward the definition of solutions in terms of policy interventions.

Detailed description of the approach

The data input is based on the SCREEN methodology, composed by a set of data sheets listed in Figure 1: some of them are expected to be filled in by the local stakeholders (companies and research centers)

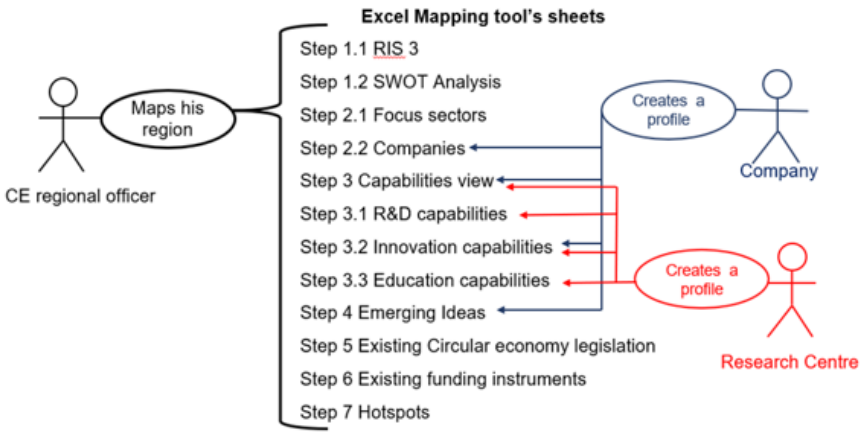


Figure 1: Data sheets to be filled in

The added value provided by the Open Innovation approach is given by enabling local stakeholders, particularly SMEs and industries, to directly insert their data, more detailed than the ones provided by the regional officers, and to be directly notified about eventual circular business opportunities, thus increasing their competitiveness and sustainability. Notifications to local stakeholders happen only after a matching detected by the automated mechanisms described in the following; therefore, the chance of being notified is related to the amount of data uploaded. Since the platform will be developed at European level and the data requested to the companies are relatively simple and not related to any process detail, the potential advantages for private stakeholders are relevant with respect to the time to be dedicated to the registration. The scheme in Fig. 2 shows how the automated mechanisms replace the previous human operated ones, with the only exception of the regional mapping tool preparation.

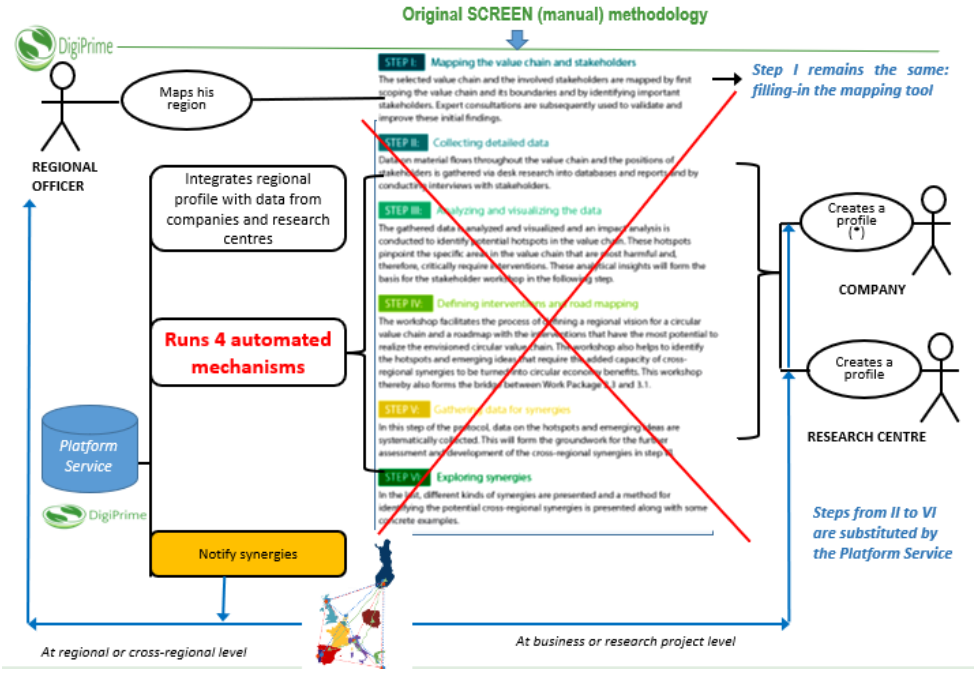


Figure2: scheme of the procedure

There are two different output types:

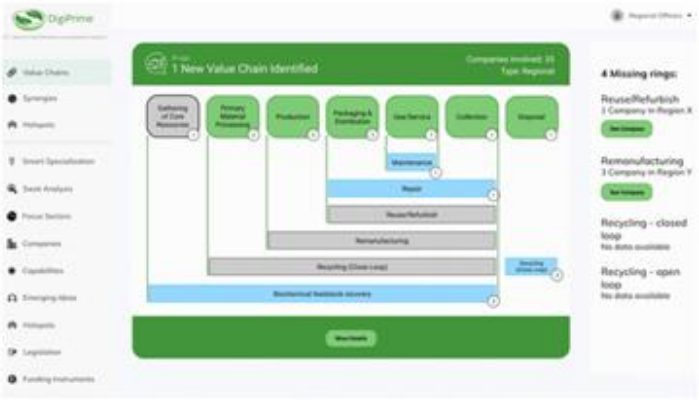
<u>For regional officers:</u>

- Dashboard with data related to circular economy in the region, automatically updated each time a new local stakeholder provides inputs.
- Notification of possible cross sectorial and/or cross regional circular value chains.
- Notification of possible solutions (through innovation or research capabilities) of regional circular economy issues

<u>For local stakeholders:</u>

- (Companies) Notification of circular economy synergies with other companies inside or outside the region; notification of possible business opportunities.
- (Research centres) Notification of research needed by companies or regional authorities.

Dashboard available for regional officers providing an overview of all the data inputted (also by local stakeholders)



Notification of potential circular value chains , including those "missing rings" available in other regions

Figure 3: outputs examples

9.3.6 Pilot 6 Circular Innovation Hubs Integration

Problem description

- Information asymmetries across value chains: Insufficient intelligence and evidence on 'viability' of circular business cases/technologies across value chains
- Disconnected demonstration infrastructure in Europe, which hampers proper investigation of such viability

Challenges

- Connecting demonstration infrastructure in Europe at the adequate level of granularity, i.e. per application domain
- Connecting demand (i.e. companies asking for solutions/support to deploy circular business cases) and supply (companies or technology centers able to offer solutions/support to do so)

Overall approach (focus on the innovation sources)

- "Circular Innovation Hubs" are designed as connected pilot facilities to serve companies in multiple sectors and across existing value chains
- To test viability, to increase visibility and to de-risk downstream private investments in new circular industrial cases

Use-cases and involved sectors (input and output sectors)

The demonstration will be carried out by adopting the platform for connecting nodes and regional infrastructures for specific cases detected earlier on during the project (pilots and task 3.6). Initial demonstration will be carried out by connecting regional infrastructure from the "De-and Remanufacturing for Circular Economy" network (partnership under the Vanguard Initiative with partners located in Lombardy, Basque Country, Tampere, Flanders, Scotland, Emilia Romagna, Norte, and Saxony). Other inter-regional partnerships, such as the 3D printing network, networks of Digital Innovation Hubs or other SP3 partnership will be also investigated.

Involved DigiPrime services

This pilot aims to demonstrate the effectiveness of the DigiPrime platform in supporting the integration and business operations of European networks of Circular Innovation Hubs. After the identification of potentially meaningful circular business cases (under pilot 5), pilot 6 will offer customized support to further define and specify the case so that partners can be identified, approached and matched to provide support and test the technical and economic viability of the circular business case. .

Detailed description of the approach

This task will demonstrate the platform functionality while supporting Circular Innovation Hubs in their operation and service delivery activities to the end users of these pilot facilities. The services provided by the DigiPrime platform, in particular those developed in T3.6 and T3.8, will be adopted and data about the capabilities of the pilot infrastructures will be populated. Then the service portfolio offered by the network will be visualized in the relevant nodes of the cross-sectorial federation and the delivery of services will be supported by the platform for at least 1 year of pilot network operation. The target goal of this pilot is to attract at least 15 new customers for the pilot network through the use of the platform along the year of operation monitored during the pilot.

Images and schemas (1-2)